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TREE SUSCEPTIBILITY STUDIES ON BLACK'S MOUNTAIN EXPERIMENTAL FOREST. A PROGRESS REPORT.

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By
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Berkeley, California
February 26, 1938

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February 26, 1938

TREE SUSCEPTIBILITY STUDIES ON BLACK'S MOUNTAIN EXPERIMENTAL FOREST.

A PROGRESS REPORT.

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TREE SUSCEPTIBILITY STUDIES ON BLACK'S MOUNTAIN EXPERIMENTAL FOREST

A PROGRESS REPORT

by

J. W. Bongberg

Introduction.

The ponderosa and Jeffrey pine stands typical of northeastern California are, for the most part, over-mature and susceptible to insect depredations. In recent years insects have played an important role in the rapid depletion of the merchantable volume in these stands. Several attempts have been made to reduce this depletion by applying direct control measures against the insect broods in the infested trees. For the most part, only a temporary reduction in subsequent infestations has been obtained.

The selective cutting of virgin forests is a way in which depletions may be reduced. In the standard marking practice of the U. S. Forest Service approximately 80% of the stand and the majority of the susceptible trees are removed. Records on cutover plots show that on all plots, the infested volume is much less than that destroyed in the virgin stands. However, when 80% of the stand is being removed by logging, relatively small areas are covered during a single season. As these areas are being logged, insect losses continue unchecked over the remaining uncut area.

A light selective cutting practice based on entomological factors and removing only those trees that are relatively susceptible to insect attack has not been given extensive application. If only susceptible trees could be removed in a light selective cutting, a much larger area could be covered during a single season than is now being covered on standard timber sale areas. As the susceptible trees would be removed, the character of the stand would be changed and the control effects might be more permanent than those secured by direct control. In this way it might be possible to save many of the trees now being rendered worthless through insect attack.

A selective or sanitation cutting program on the Black's Mountain Experimental Forest has been developed to test if such a selection is practical and determine what effect this type of cutting has on subsequent insect loss.

Cooperation.

The Black's Mountain Selective Cutting Project is a cooperative one. The California Forest and Range Experiment Station has extended to the Bureau the use of certain of the facilities at their Black's Mountain Branch at Hall's Flat. The Experiment Station is to carry on the field work in connection with the logging and will develop a program of experimentation in forest management and silviculture. The Bureau is cooperating by studying entomological problems and phases of the work at Black's Mountain.

Black's Mountain Experimental Forest. (2)

The Black's Mountain Experimental Forest has been set aside for experimental work. It is comprised of 9825.7 acres of Government land in T. 33 N., R 7 & 8 E., M.D.M., in the Lassen National Forest, California. Approximately 167,806 M.B.M. of timber occurs on 9078.1 timbered acres. 7134.7 By volume, the stand consists of ponderosa and Jeffrey pine (90.5%), white fir (6.5%), and incense cedar (3%). The site class ranges between III and IV with a site index of 114' at 300 years. Individual trees and groups of trees range in age up to 600 years with 95% of the volume represented in trees over 120 years of age. This area was chosen to "test and demonstrate the practice of sustained yield forestry in the east side ponderosa pine forests of low site quality in northeastern California." (2)

The forest has been divided into five separate blocks, namely Black's Mountain, Cone Mountain, Patterson Mountain, Grass Valley and Aspen Flat. Each block contains a number of compartments, each of which is to be treated as a separate logging unit. Four primary roads and several secondary roads traverse the area. This system of roads makes possible the removal of logs from any single compartment without disturbing conditions elsewhere.

One compartment in each block has been set aside as a natural area in which the Bureau intends to study infestation trends under natural conditions. These five compartments represent a total of 526 acres. In addition, approximately 200 acres have been reserved for entomological use. Cutting on this acreage will be limited to susceptible trees and studies will be planned to find out what changes take place in a stand when only susceptible trees are removed. The blocks, roads, compartments and reserved areas are shown on the appended map.

Objectives:

Management:- The present sanitation cutting program on the Black's Mountain Experimental Forest which removes those trees considered to be susceptible to insect attack is an outgrowth of original plans drawn up by the Experiment Station for testing and demonstrating the practice of sustained yield forestry on this area. Because of heavy insect caused losses it was found that the application of silvicultural practices and the development of methods for sustained yield forestry was not possible until

control of the entomological factors was obtained. The sanitation cutting program is an attempt to obtain control of the entomological factors and to reduce subsequent insect loss to a point where management for sustained yield may be possible. The ultimate objective of the Experiment Station is the development of satisfactory methods for managing "east side" forest areas.

Entomological:- The Bureau of Entomology has for years been trying to develop either indirect or direct methods for controlling activities of insects in commercial forests. The primary objective in this study is to develop and test an indirect control method involving the periodic removal of susceptible trees in an effort to make the stands more resistant to insect attack and to reduce insect caused loss. This objective draws on the results of many completed and partially completed biological and control investigations. The fact that incipient flatheaded borer infestations are found in many green trees and that these infested trees appear to be highly susceptible to barkbeetle attacks is the chief factor in determining tree susceptibility. The important points to be considered in reaching the primary objective are as follows:

1. Develop and test a system for classifying the susceptibility of green trees to insect attack.

2. Determine the proportions, distribution in the stand, and general relations of the susceptible elements to the stand as a whole.

3. Test the accuracy of application of the susceptibility classification.

4. Determine if the removal of susceptible trees from the stand reduces subsequent insect caused loss.

Methods.

A crew of three men was used in applying the tree susceptibility classification to the green pine stand on portions of the Experimental Forest during 1937. This crew consisted of:

1. Estimator. An estimator classified all trees on a basis of crown and foliage characters and noted the species, d.b.h., and tree and susceptibility class of each.

2. Marker. The marker measured the diameters and marked all trees that were classified. White paint spots were used to indicate the susceptibility classification, the number of spots denoting the degree of susceptibility.

3. Compassman. A compassman recorded the location of the high risk trees and carried additional marking supplies.

Data were analized separately for each compartment. All trees were segregated by species, d.b.h., and tree susceptibility classes. The diameter distribution and volume distribution by diameters was determined for the 1933-36 insect losses, the 1937 green stand, for each of the four susceptibility classes, and for the trees removed by the sanitation cut. These segregations were calculated on a basis of loss, volume, percent of stand or accumulated percent, depending on the factor being analyzed. A study was made of the relation of the susceptibility marking and the marking that would have been practiced in applications of Dunning's (1) and Keen's (3) systems.

Progress During the 1937 Season.

Loss History:- A 100% stand cruise of the Experimental Forest was made by the Experiment Station during 1933 and 1934. Since that time insect losses have accumulated without a yearly record being taken. Due to the fact that the four years of loss have materially reduced the merchantable volume on the area, a cruise to determine this depletion was started during the season of 1937. This cruise was conducted by Experiment Station personnel and each dead tree was recorded by d.b.h., and Dunning's tree class. Losses were segregated by compartments and the current infestation was kept separate from that of the three previous years. In this way the present conditions and the trend of the infestation could be estimated. Losses were found to have been decreasing since the peak of the infestation late in 1934 or early in 1935. The average pine loss on the Experimental Forest has been 157.3 board feet per acre per year for the four year period. (1933 to 1936 inclusive) Loss on individual compartments has ranged from zero to 428 board feet per acre per year. A summary, which has been taken from the Experiment Station's summary of the loss cruise, is presented in table 1.

Table 1

Pine Losses on the Black's Mountain Experimental Forest. 1933-36 incl.

Block No.	Timbered acreage	Number of trees	Trees per acre	Trees per acre/yr.	Total volume	Volume per acre	Volume per acre/yr.
B	1173.5	1032	.88	.22	1,096,330	934.2	234
C	2354.0	1470	.63	.16	1,675,703	704.2	176
P	1994.4	1186	.60	.15	1,335,079	669.4	167
G	2799.2	1326	.47	.12	1,433,839	512.2	128
A	788.1	124	.16	.04	209,830	266.3	67
Total:	9109.2	5138			5,732,781		
Aver.:			.56	.14		629.3	157

Green Stand:- In classifying portions of the Experimental Forest during 1937, it was found advisable to measure the diameter of every tree classified so that the total green stand could be accurately determined. The majority of the trees were found to be mature and over-mature. The stand resources on the compartments that were classified during 1937 are shown in the following table.

Table II

Total Green Stand Classified During 1937.

Compartment number	Timbered acreage	Number of trees	B.M. volume	Trees per acre	Volume per acre
G0-14	78.3	1717	1,329,984	21.9	16,986
G2-12	140.0	2850	2,420,888	20.4	17,292
G2-14	82.0	1779	1,294,355	21.7	15,785
G4-15	108.2	2482	2,147,944	22.9	19,852
G8-10	67.4	1318	1,210,438	19.6	17,959
B24-7	101.7	2093	1,649,816	20.6	16,222
B30-1	84.2	1217	1,335,674	14.5	15,863
B30-3	83.4	1265	1,326,858	15.2	15,910
B30-6	133.0	2392	2,113,192	18.0	15,889
C4-21	71.3	1599	1,227,962	22.4	17,222
Total	913.5	18,712	16,057,111		
Average				20.5	17,578

Susceptibility Marking:- A tentative susceptibility classification has recently been developed by the bureau of Entomology and Plant Quarantine in which susceptible trees are identified by using crown characters that show symptoms of incipient flathead infestations. The present classification is applicable only to ponderosa and Jeffrey pine and its use is intended more when infestations have an endemic nature rather than that of an epidemic.

When the susceptibility classification was first applied to the green stand only three classes were used. Trees were rated as being high risk, intermediate risk, or low risk. (classes III, II and I respectively) When it was found that trees having a wide range of susceptibility were being grouped in class II, the classifiwation was changed to its present form, containing four classed. These classes as now being used, are as follows:

Class IV. Trees that either show definite evidence of weakness caused by the immature stages of the California flatheaded borer or have active, usually topkilling, infestations. These trees will most likely be the first to succumb.

Class III. Trees in which the incipient flathead infestation is less marked than in class IV. However, indications of weakness are definite enough to warrant class III trees as being highly susceptible and their removal from the stand is considered advisable.

Class II. Trees in which characters indicate only a slight possibility of the presence of incipient infestations in portions of the crown.

Class I. Trees considered to be in perfect health.

Classes IV and III contain trees representing high risk.

Classes II and I contain trees representing low risk.

Ten compartments totaling 913.5 timbered acres were classified during 1937. All of the green trees over 12" d.b.h. or a total of 18,712 trees were marked in the four susceptibility classes. The distribution of the four susceptibility classes on a typical compartment and their relation to the total green stand of 1937 is shown in figure 1. The per cent of the total number of trees marked in each susceptibility class for each of the ten compartments is shown in table 3. The highly susceptible trees that were marked for removal on the 10 compartments are shown in table 4.

Table 3.

Susceptibility Classification of 1937 Stand. (10 Compartments)

Compartment number	Timbered acreage	Sus. Class I: Percent Trees	Sus. Class I: Percent Vol.	Sus. Class II: Percent Trees	Sus. Class II: Percent Vol.	Sus. Class III: Percent Trees	Sus. Class III: Percent Vol.	Sus. Class IV: Percent Trees	Sus. Class IV: Percent Vol.
G0-14	78.3	67.4	59.2	18.6	23.3	8.3	9.9	5.7	7.6
G2-12	140.0	66.7	54.4	20.2	27.1	6.3	9.1	6.8	9.4
G2-14	82.0	77.4	70.4	12.9	14.8	4.2	5.7	5.5	9.1
G4-15	108.2	73.3	66.1	17.7	21.9	4.8	6.6	4.2	5.4
G8-10	67.4	78.3	71.3	12.5	15.9	4.4	6.2	4.8	6.6
B24-7	101.7	71.9	58.2	16.6	23.6	6.1	9.7	5.4	8.5
B30-1	84.2	74.3	61.6	17.0	24.8	5.5	8.5	3.2	5.1
B30-3	83.4	69.4	54.2	20.7	30.8	5.3	8.1	4.6	6.9
B30-6	133.0	69.2	51.7	20.6	32.1	6.2	9.8	4.0	6.4
C4-21	71.3	73.8	65.0	18.2	23.2	5.3	6.5	3.7	5.3
Average		71.6	60.3	17.8	24.4	5.7	8.2	4.9	7.1

Table 4.

Highly Susceptible Trees. (Classes III and IV)

Compartment number	Number of trees	Percent	B.M. volume	Percent
G0-14	240	14.0	232,790	17.5
G2-12	374	13.1	446,620	18.5
G2-14	173	9.7	190,590	14.8
G4-15	225	9.0	260,020	12.0
G8-10	122	9.2	155,290	12.8
B24-7	240	11.5	300,530	18.2
B30-1	106	8.7	182,580	13.6
B30-3	126	9.9	198,260	15.0
B30-6	242	10.2	343,730	16.2
C4-21	144	9.0	144,210	11.8
Total	1,992		2,454,620	
Average		10.6		15.3

The cumulative distribution of the four susceptibility classes is shown in figure 2. From this curve it is possible to determine the percent of the 1937 volume that would be removed in susceptible trees if a cutting operation were based on a given minimum diameter limit.

Sanitation Cutting:- During the 1937 season the Experiment Station made plans to remove, in a light selective cutting, a minimum of 600,000 board feet in trees of high risk. This volume was to be delivered to the railroad landing in saw-logs of standard value and sold to the Fruit Grower's Supply Company by log grades. It was considered that by removing 2500 board feet per acre from three compartments this volume would be secured. The marking of high risk trees (classes III and IV) did not meet this demand in all cases and it was found necessary to select a few additional trees of somewhat higher value and lower risk. Therefore, the sanitation cut not only removed all trees in classes III and IV, but in addition a few from classes II and I. The distribution of the sanitation cut by susceptibility classes is shown in figure 3.

The mechanics of the cutting program were worked out by the Experiment Station and 496 trees were removed from 240 acres. According to the Experiment Station's summary of the sanitation cutting program, a total of 625,570 board feet was cut and delivered to the railroad landing during 1937, an average of 2604 board feet per acre.

Preliminary Observations.

Results obtained during this first season's work are of a tentative nature and will be subject to modification as additional data

are secured. However, preliminary observations on the factors and relations mentioned below can be made from the data at hand.

Relation of Loss and Susceptibility:- The high risk trees (classes IV and III) are thought most likely to be the ones going to make up the majority of the insect loss on the Experimental Forest in the near future. However, until we can secure an accumulation of loss records for trees that have been classified while living, there will be no way of knowing definitely that these trees are the ones making up the greater portion of the loss. Until such a record can be secured, the following comparisons may provide some indication of the relations of our marking and loss.

By comparing losses with high risk trees, a similar stand and tree class distribution should be found. The distribution of trees making up the past four years' losses shows that diameters between 22 and 32 inches d.b.h. occur most frequently in the record. The distribution for a typical compartment is shown in figure 4. The distribution of highly susceptible trees (figure 5) was found to occur more often in diameters between 20 and 30 inches d.b.h. This similar diameter distribution seems to indicate a relation exists between losses and highly susceptible trees. The difference in percentages of each diameter class is accountable in that the loss record includes only a four year period whereas the highly susceptible trees may be the loss for a much longer period of time. The diameter distribution of loss and of the susceptible trees compares quite favorably with results reported upon by Person (4).

Dunning (1) studied the "relative liability to loss, or the ratio of occurrence in the losses to occurrence in the stand as a whole" in a green stand of 4669 trees in the Sierra Nevada region and assigned 172 insect killed trees to their proper places in his tree classification. By using 10 classified compartments on the Experimental Forest for a comparison of loss with high risk trees a "ratio of occurrence" should be found similar to that secured by Dunning. In those 10 compartments we find agreement in only two of Dunning's seven classes. However, when we consider the relation of loss and susceptibility in terms of volume, it is found that even though agreement did not occur in all classes, agreement was reached in 93% of the total volume represented. Since this per cent of the volume is almost entirely in high grade trees, the loss in the other classes has small value. The loss and susceptibility ratios in terms of volume are shown in figure 6.

Keen (3) has developed a tree classification based on barkbeetle susceptibility. In this classification he has shown the "relative susceptibility" of green ponderosa pine trees. It was found that "the liability to loss" was highest in classes of low crown vigor. General resistance to barkbeetle attack was found to occur in classes of high crown vigor. The majority of the susceptible trees in the stand as a whole were in the mature and over-mature age classes.

The high risk trees marked on 10 compartments of the Experimental Forest follow this same general grouping. The trees marked as highly

susceptible in the new classification occur as larger portions in the mature and over-mature age classes and in classes of low crown vigor. The susceptible trees, in percent of the total marked in each of Keen's tree classes, is shown in the following table.

Table 5.

Susceptible Trees in Percent of Total in Each of Keen's Tree Classes.

Class	A	B	C	D	Total
1	0.1	0.5	4.1	0.0	.46
2	0.3	1.7	4.7	1.1	1.2
3	3.1	6.7	18.5	8.0	7.3
4	6.0	15.9	39.8	13.4	20.8
Total	2.7	9.2	29.6	8.1	

Accuracy of Classification:- The entire bole of practically every tree that was removed in the cutting program was analyzed for the presence of insect infestations to determine if the tree had been classified correctly. Of the total number of trees that were removed in the cutting program, 171 were classed on the three class basis. Since this classification does not agree with that now in use, those trees will be omitted in summarizing the results. A few additional trees must be eliminated from the study as they were hauled to the landing before analysis records could be taken. Therefore, 147 trees in class IV, 129 trees in class III, 35 trees in class II and 3 trees in class I remain for study. The removal of trees in class II was based primarily on value while the removal of the three other non-susceptible trees was made because they were injured during logging operations.

Before the classified trees were felled it was found advisable to recognize and note the fact that in many trees only a part of the bole length was believed to be infested by incipient flatheaded borer broods. As a result, the infested and non-infested length of the bole was estimated. Analysis data were then analyzed by number of trees and on a linear foot basis. A total of 28,675 linear feet of bole were covered by the analysis of 314 trees. Table 6 shows the analysis results and indicates the accuracy that can be secured in estimating if incipient broods are present in trees or parts of trees.

Table 6.

Accuracy of Judging Susceptibility Classes

Susceptibility classes	Number of trees			Linear Feet		
	Total	Correct	% Corr.	Total	Correct	% Corr.
Class IV	147	126	86	12,648	10,794	85
Class III	129	79	61	12,340	10,171	82
Class II	35	28	80	3,407	3,075	90
Class I	3	2	67	280	230	82
Total	314	235	75	28,675	24,270	85

Prior to the selective cutting on the Experimental Forest, analyses were made on another area being logged by the Fruit Grower's Supply Company. Of the total number of trees analyzed, 84 were of the non-susceptible type (class I). Of these 84 trees, 91% were found to be without infestation by the California flatheaded borer and were considered to have been classified correctly. The average of all classes showed a correct estimate in 79% of the trees. Therefore, from these two sets of data on areas of similar character it appears that accuracy in judging the presence or absence of flatheaded borer broods and presumably the susceptible trees range from 80 to 90%.

A comparison of records from the three compartments cut on the Experimental Forest showed that there was very little variation in the use of the characters considered to signify differences in susceptibility.

Conclusions.

A collection of data over a period of years is necessary to formulate final conclusions for a project of this type. Tentative conclusions are all that can be drawn from this first season's work. These conclusions are as follows:

1. From a comparison of analysis data for the three compartments cut during this first season, it appears that very little variation occurred in the use of crown characters in classifying trees as to susceptibility.

2. From the analysis data of 314 trees, 80 to 90% accuracy was secured in judging susceptibility.

3. An accumulation of future loss data will have to be secured before a determination can be made as to whether the removal of susceptible trees results in a reduction of subsequent loss.

4. High risk trees appear to be quite evenly distributed over the entire area that was classified during 1937.

5. A removal of all highly susceptible trees from sites III or IV in this area will yield a board foot volume of approximately 2500 feet per acre.

6. The high risk trees are distributed in practically all diameter classes and are more abundant in the predominating diameters.

7. The distribution of trees marked as high risk appears to compare favorably with the distribution of previous losses and with trees considered as highly susceptible by Dunning and Keen.

Before silvicultural practices based on entomological factors can be given extensive application to "east side" stands, additional data on tree susceptibility will have to be secured.

Plans for 1938.

The removal of susceptible trees from the Experimental Forest by light selective cutting will be continued during the coming season. Phases of the entomological work directly connected with the selective cutting program will be continued. This work will consist of the following:

1. Additional trees to be logged during 1938 will be classified according to susceptibility. Any compartments selected for cutting during 1938 will have to be classified in advance of the cutting operation.

2. An analysis should be made of every tree removed in the cutting program. It is through these records that we can secure much of the information necessary for further development of the susceptibility classification.

3. Characters used in classifying susceptible trees should be refined and standardized. Much of this work can be done through a review of the analysis data.

4. An intensive cruise of the Forest should be made to determine the insect loss during the season of 1937. This work would best be completed early in the spring of 1938 before the beginning of the cutting program.

5. A determination of the yearly change in susceptibility is of primary importance. A periodic reclassification of the susceptibility of individual trees should, over the course of a few years, show the rate of change in susceptibility.

6. Any trees that have become infested since they were classified should be felled for analysis to determine the place of the

infesting species in causing death. There were a few compartments classified as to susceptibility during 1937 that were not logged. The analysis of any infested material on these compartments will tend to supplement existing data being used in the application of tree susceptibility. This work can best be done before the insect broods emerge.

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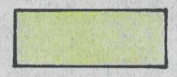
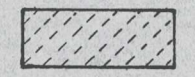
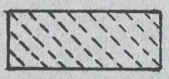
MAP LEGEND



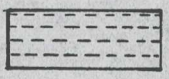
Compartments classified as to susceptibility during 1937.



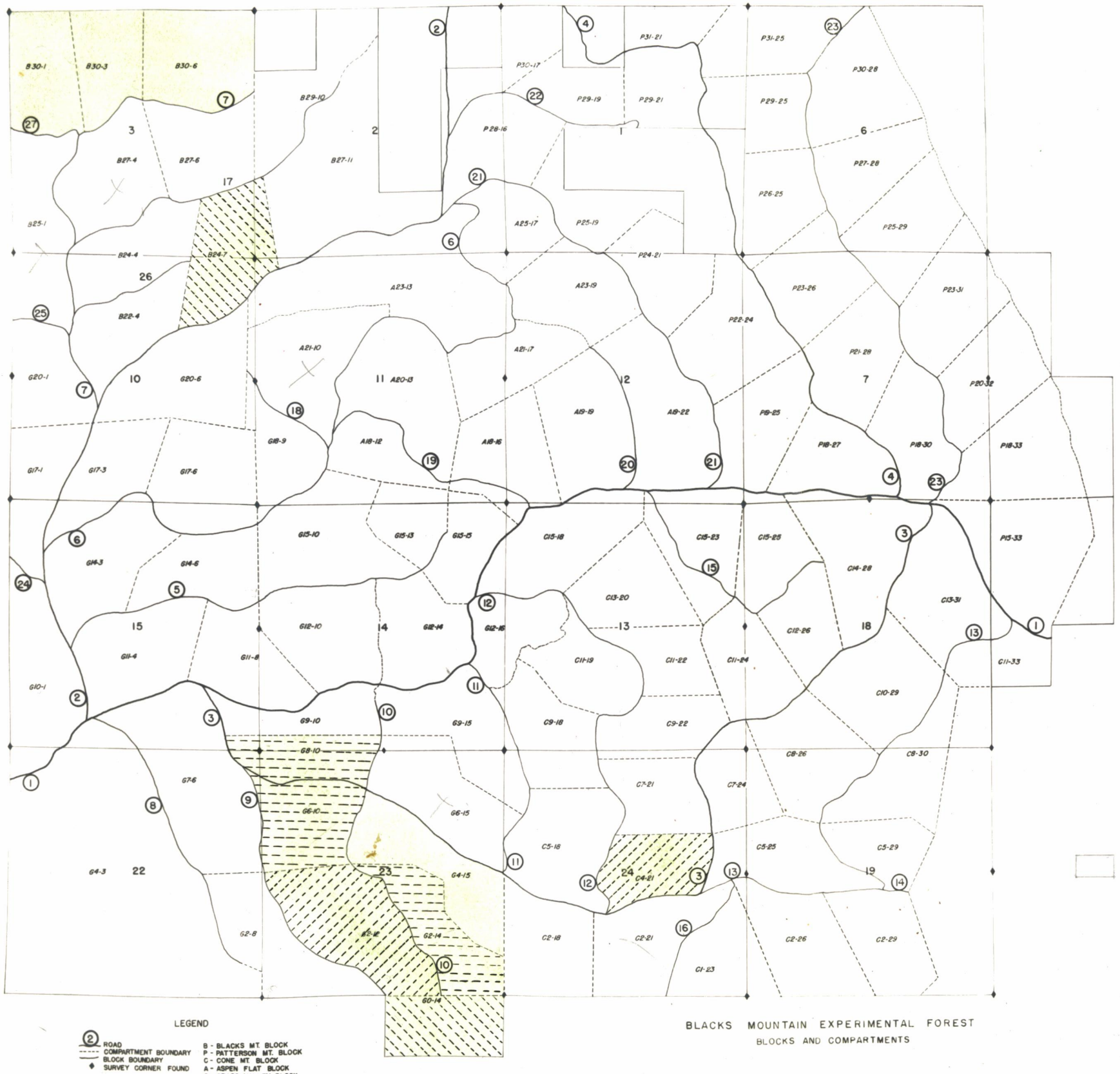
Compartments set aside as "natural areas".



Compartments set aside for removal of only highly susceptible trees.



Compartments cut in sanitation cutting program during 1937.



BLACKS MOUNTAIN EXPERIMENTAL FOREST

BLOCKS AND COMPARTMENTS

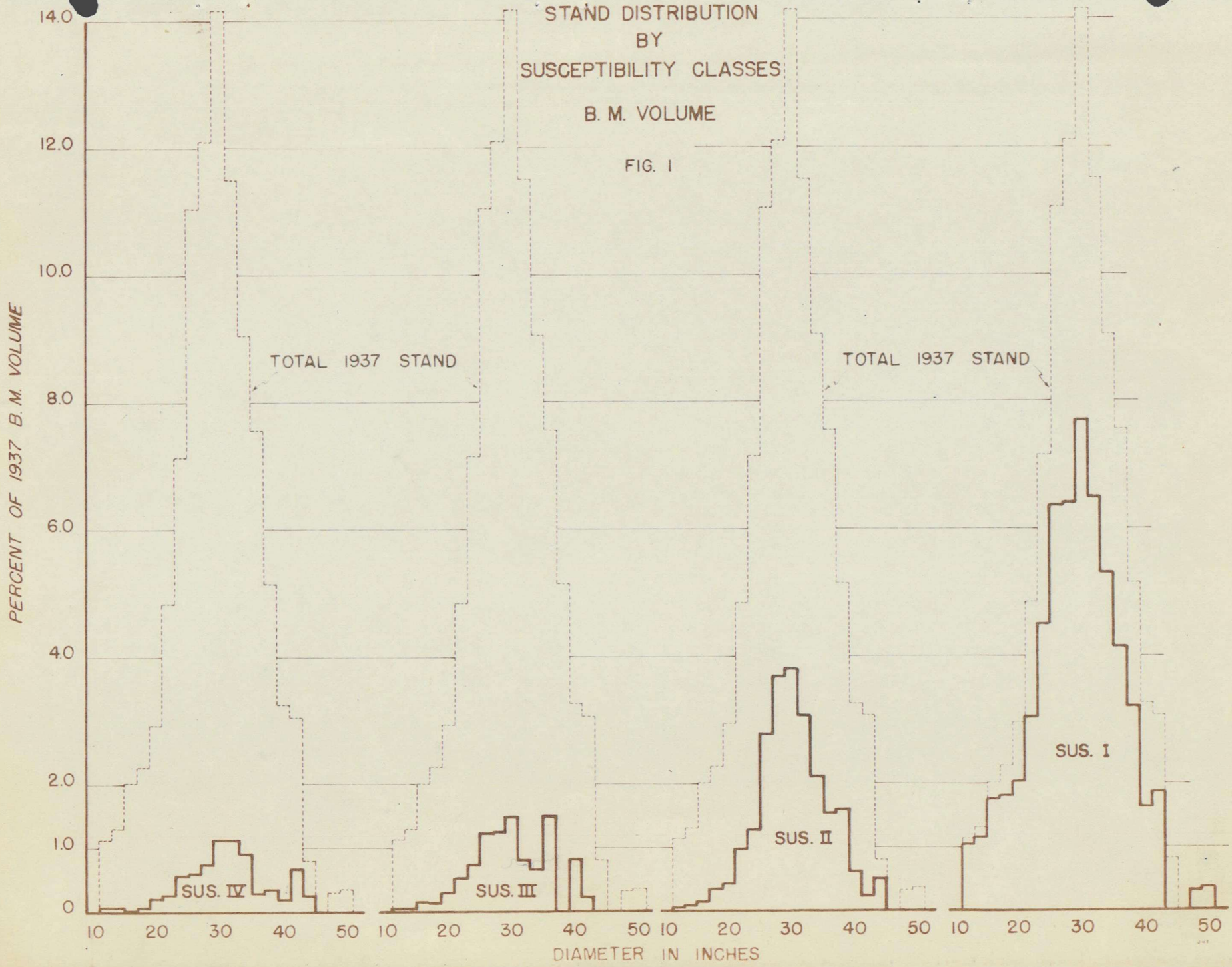

STAND DISTRIBUTION
BY
SUSCEPTIBILITY CLASSES
B. M. VOLUME
FIG. 1
PERCENT OF 1937 B.M. VOLUME
14.0
12.0
10.0
8.0
6.0
4.0
2.0
1.0
0
TOTAL 1937 STAND
TOTAL 1937 STAND
SUS. IV
SUS. III
SUS. II
SUS. I
10 20 30 40 50
10 20 30 40 50
10 20 30 40 50
10 20 30 40 50
DIAMETER IN INCHES

FIGURE 2

CUMULATIVE STAND CURVES
OF
SUSCEPTIBILITY CLASSES
IN PERCENT OF
1937 B.M. VOLUME

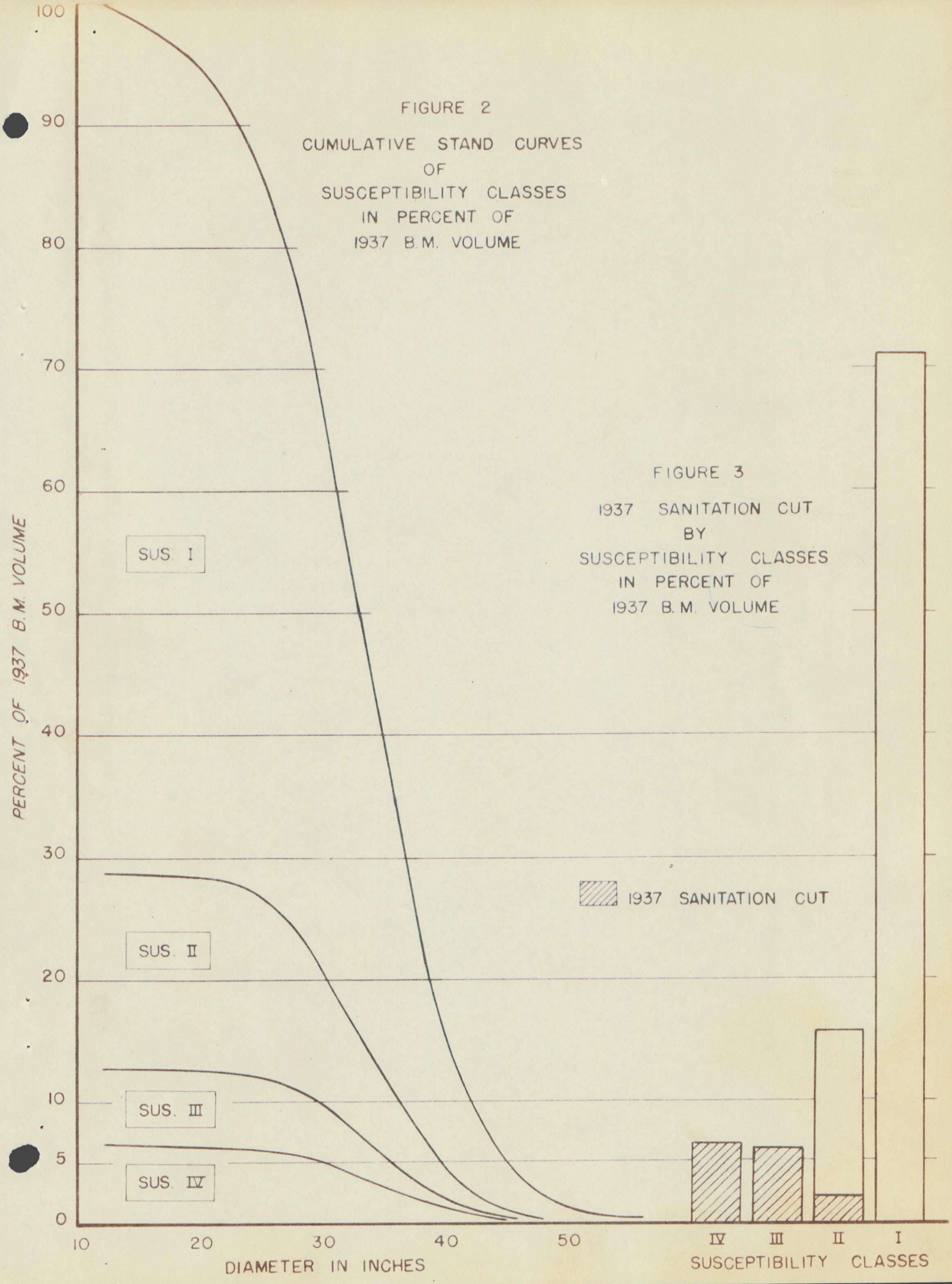


FIGURE 3

1937 SANITATION CUT
BY
SUSCEPTIBILITY CLASSES
IN PERCENT OF
1937 B.M. VOLUME

FIGURE 4

DISTRIBUTION
OF
INSECT LOSSES
1933-36 INCLUSIVE

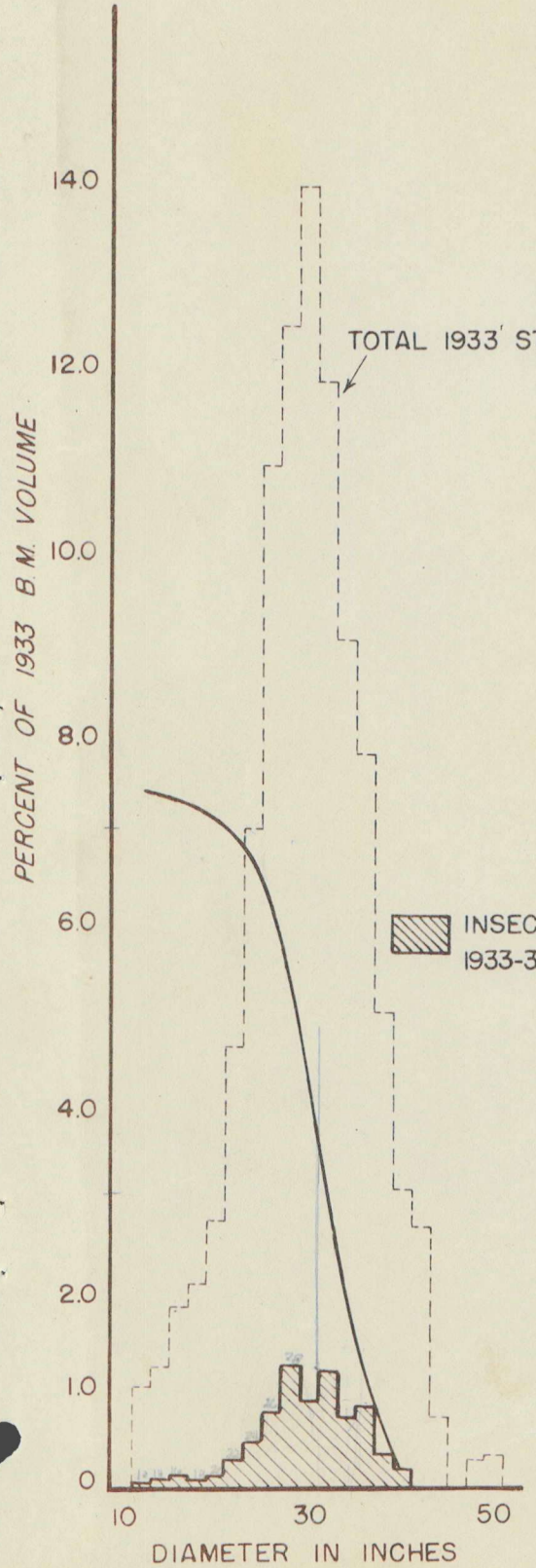
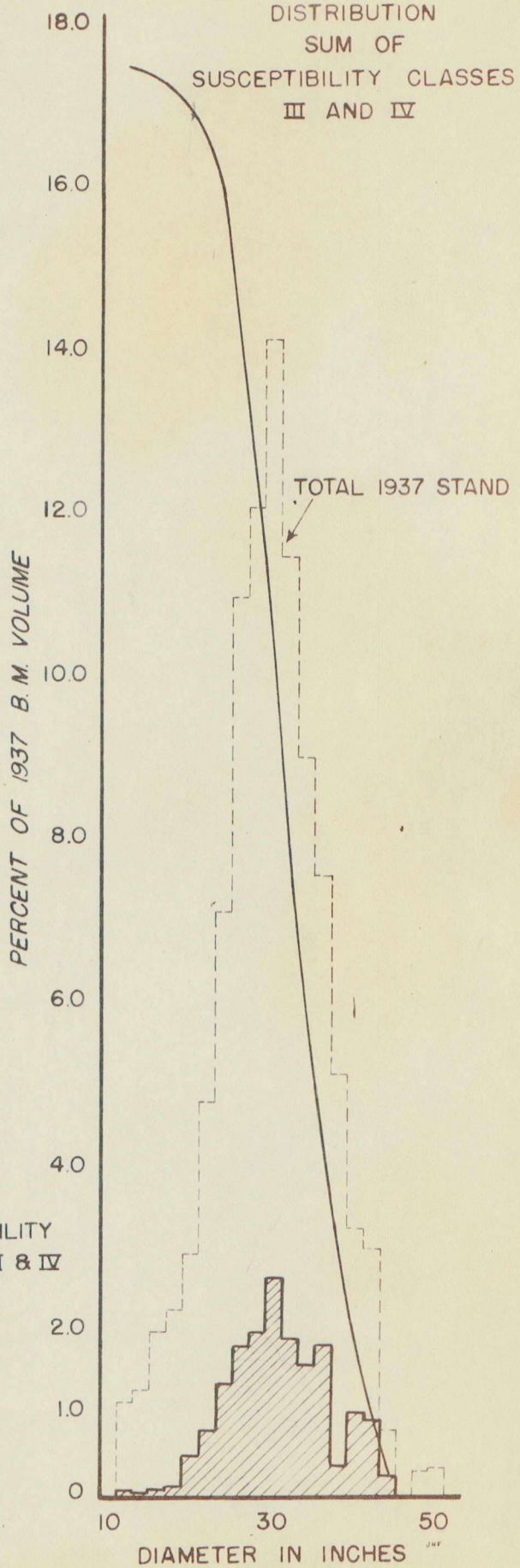


FIGURE 5

DISTRIBUTION
SUM OF
SUSCEPTIBILITY CLASSES
III AND IV



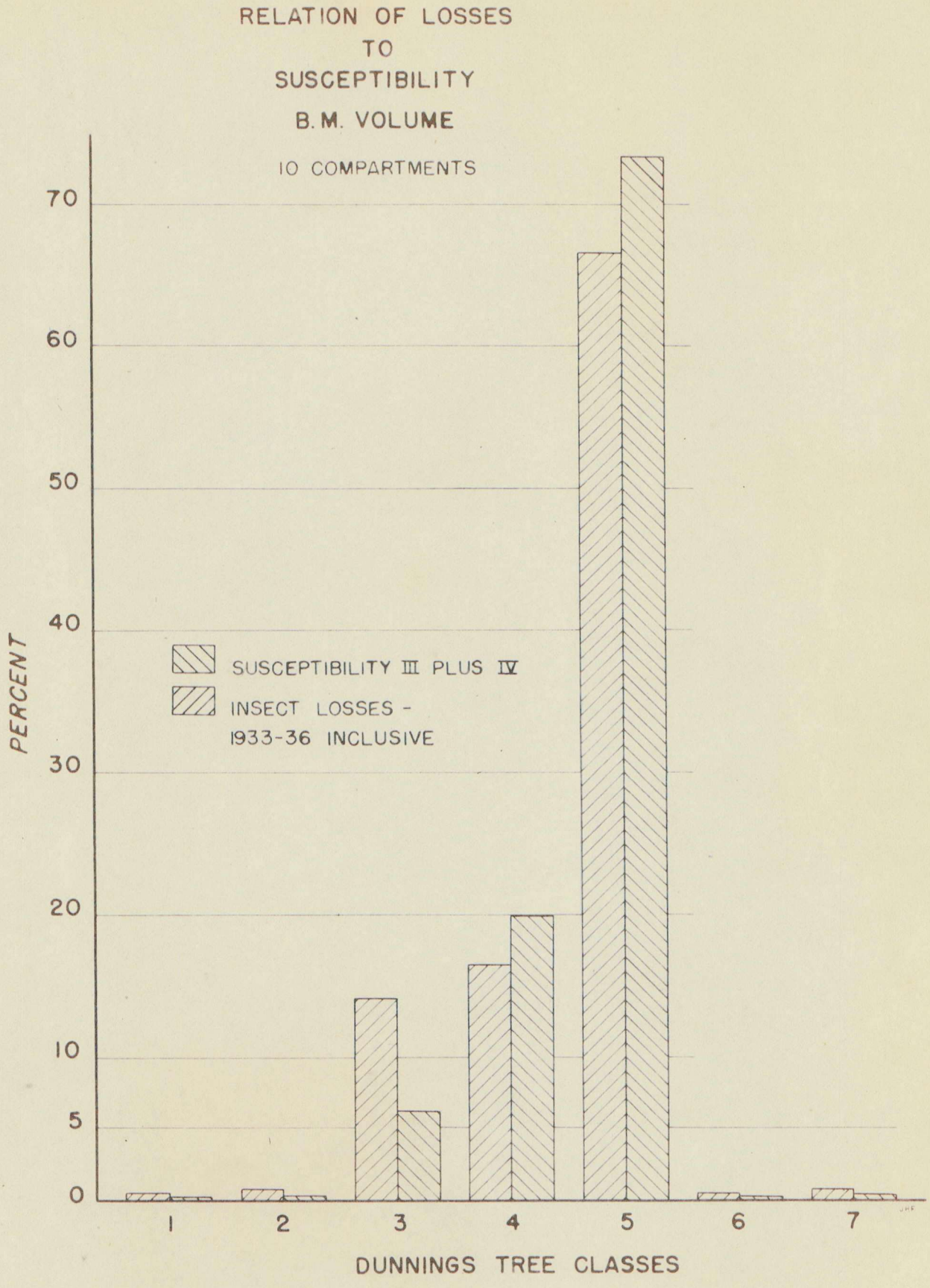

RELATION OF LOSSES
TO
SUSCEPTIBILITY
B.M. VOLUME
10 COMPARTMENTS
70
60
50
40
30
20
10
5
0
PERCENT
SUSCEPTIBILITY III PLUS IV
INSECT LOSSES -
1933-36 INCLUSIVE
1
2
3
4
5
6
7
DUNNINGS TREE CLASSES

FIG. 6

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Compartment number	Timbered acreage	Total No. of trees	Total B.M. Volume
G0-14	78.3	1717	1,329,900
G2-12	140.0	2850	2,420,900
G2-14	82.0	1779	1,294,400
G4-15	108.2	2482	2,147,900
G8-10	67.4	1318	1,210,400
B24-7	101,7	2093	1,649,800
B30-1	84.2	1217	1,335,700
B30-3	83.4	1265	1,326,900
B30-6	133.0	2392	2,113,200
C4-21	71.3	1599	1,228,000
Total	913.5	18712	16,057,100

Basis for Averages

Sus. Class I		Sus. Class II		Sus. Class III		Sus. Class IV	
Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume
13,394	9,690,000	3,326	3,912,500	1,070	1,310,110	922	1,144,500